(12) **EUROPEAN PATENT APPLICATION**

published in accordance with Art. 158(3) EPC

(71) Applicant: Fanuc Ltd
5-1, Asahigaoka, 3-chome
Hino-shi, Tokyo 191(JP)

(72) Inventor: FUKUYAMA, Hiroomi
719-644, Yano-cho Hachioji-shi
Tokyo 192(JP)

(72) Inventor: ISOBE, Shinichi
Hinodai-Haitsu 516, 1-1-1 Hinodai, Hino-shi
Tokyo 191(JP)

(72) Inventor: SHIMA, Atsushi
2-39-13-1002, Kamiogi Suginami-ku
Tokyo 167(JP)

(74) Representative: Billington, Lawrence Emlyn et al,
HASELTINE LAKE & CO Hazlitt House 28 Southampton
Buildings Chancery Lane
London WC2A 1AT(GB)

(54) NUMERICAL CONTROL DEVICE.

(57) In a numerical control device having a spindle speed direct instruction means (11a) for instructing a spindle speed directly and a position detecting means (20) for detecting the present rotational position of a spindle (17), means (11b) for generating the deviation between the instructed rotational position and the present rotational position and switching means (11a) are provided. When controlling the speed of the spindle, a speed command issued from the spindle speed direct instruction means (11a) is input through the switching means to a spindle speed controlling circuit (12), and by controlling the position of the spindle, the positional deviation is input through the switching means to the speed controlling means, thereby stopping the spindle at the instructed rotational position.
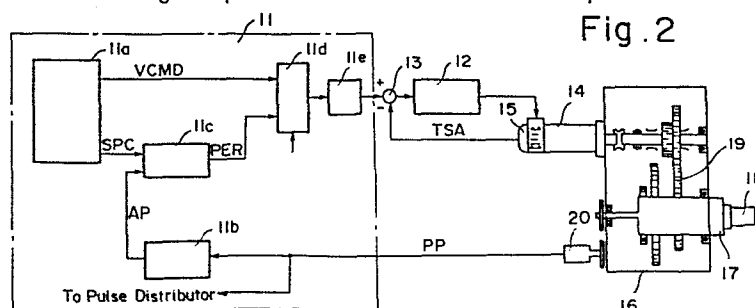
Fig. 2

EP 0 078 855 A1

DESCRIPTION

NUMERICAL CONTROL DEVICE

Technical Field

This invention relates to a numerical control

5 device and, more particularly, to a simply constructed

numerical control device which has a spindle indexing

function and which is capable of controlling both the

speed and angular position of a spindle.

Background Art

10   Numerically controlled machine tools are adapted

to subject a workpiece to machining such as turning,

thread cutting and tapping while a spindle is being

rotated at a predetermined speed. In general, the

rotational speed of the spindle is commanded indirectly

15 by a numerical control device (referred to as an NC)

with a command in the form an S-function instruction

$S_{\Delta\Delta}$, whereby the machine tool is made to rotate the

spindle at a speed in accordance with a two-digit

numerical value that follows the letter of the alphabet

20 S. Recently, a method of commanding the rotational

speed of a spindle directly has been proposed wherein

the rotational speed of the spindle is commanded

directly by means of a four-digit numerical value

following the letter S, the numerical value being

25 subjected to a DA conversion for application to a speed

control circuit. An advantage gained with the direct

command method is fine control of speed.

A frequent requirement recently in numerically

controlled machine tools is that the spindle be
stoppable at any angular position with great accuracy.
When milling, drilling or tapping a workpiece at a
predetermined angular position thereon by means of a
5 lathe or turning center, for example, it is necessary
to bring the spindle to rest at the predetermined
angular position.

Fig. 1 is a view showing screw holes 2a, 2b, 2c,
2d, a keyway 3 and holes 4a, 4b formed in a turned
10 workpiece 1 at predetermined angular positions. These
screw holes, keyway and other holes may be machined in
the following manner, which serves as an example only.
First, the workpiece 1, held in a chuck which is not
shown, is driven by a spindle drive motor and brought
15 to a predetermined angular position, whereby the
position on the body of the workpiece at which the
workpiece is to be machined is faced toward a rotary
tool, after which the tool is driven into rotation to
machine, say, a screw hole. Thus, in a numerically
20 controlled machine tool, it is required that the
spindle be stopped, with great accuracy, at any angular
position in line with the particular goal.

In the prior art, the foregoing is achieved by
providing separate systems for controlling spindle
25 speed and position, whereby spindle speed and position
are controlled independently. Alternatively, an
already existing spindle speed control system is
supplemented with a structurally complex control unit,

provided externally of the NC, for stopping the spindle
at a predetermined position.

Accordingly, the conventional methods are attended
by such disadvantages as a need for considerable
hardware, as well as complex and costly circuitry and a
complicated control operation.

The object of the present invention, therefore, is
to provide a numerical control device which, through a
very simple method and very little additional hardware
or only slight alteration of NC software, enables both
the speed and position of a spindle to be controlled.

Disclosure of the Invention

According to the present invention, in an NC
equipped with spindle speed direct command means for
commanding the rotational speed of a spindle directly,
and sensing means for sensing the actual angular
position of the spindle, the NC, which controls the
speed of the spindle by the direct command, is merely
provided with a register for storing the actual angular
position of the spindle, an arithmetic circuit for
computing a positional offset, and a switching circuit,
so that a loop can be formed for controlling both the
rotational speed and the angular position of the
spindle.

Brief Description of the Drawings

Fig. 1 is an explanatory view for explaining the
necessity of controlling the position of a spindle, and
Fig. 2 is a circuit block diagram of the present

invention.

Best Mode for Carrying Out the Invention

Fig. 2 is a circuit block diagram illustrating an
embodiment of the present invention.   In Fig. 2,

5 numeral 11 denotes an NC which includes a command unit
11a for producing a speed command VCMD issued directly
on the basis of a digital value of four digits which
follow the letter S, as well as a spindle position ·
command SPC, a register PER for storing the actual

10 angular position of a spindle by counting up or
counting down, in accordance with the direction of
rotation, position pulses PP each of which is generated
whenever a pulse coder, described below, rotates by a
predetermined amount, an arithmetic circuit 11c for

15 producing, in digital form, a positional offset PER
between a commanded angular position for the spindle
and the actual angular position of the spindle, a
switching circuit 11d for switching between and
delivering, in accordance with a speed control mode or

20 position control mode, either the speed command VCMD or
the positional offset PER (a digital value) produced by
the command unit 11a, respectively, and a DA converter
11e.

Numeral 12 denotes a speed command circuit which

25 incorporates a phase compensating circuit, a
voltage/phase converter, and a thyristor circuit, these
not being illustrated in the drawings.   Numeral 13
denotes an adding-subtracting circuit which, in speed

control, produces a differential voltage (speed devia-
tion) between the speed command VCMD and an actual
speed voltage TSA and, in position control, produces a
differential voltage between the positional offset PER

5 and the actual speed voltage TSA. Numeral 14 desig-
nates a DC motor, and 15 a tachogenerator for generat-
ing the actual speed voltage in accordance with the
rotational speed of the DC motor 14. Numeral 16
denotes a gear box, 17 a spindle, 18 a workpiece, 19

10 gears, and 20 a pulse coder such as a position coder
for generating a position pulse PP each time the
spindle rotates by a predetermined amount, as well as a
one-revolution signal (not shown) each time the spindle
makes one full revolution.

15 In the speed control mode, the switching circuit
11d delivers the speed command VCMD to the DA converter
11e. The latter converts the speed command VCMD into
an analog value and applies it to the arithmetic
circuit 13 which, upon computing the difference between

20 the speed command VCMD and the actual speed voltage
TSA, delivers the difference to the speed control
circuit 12. The speed control circuit 12 executes
speed control in such fashion that the speed deviation
approaches zero, thereby rotating the spindle 17 at the

25 commanded speed. As the spindle rotates, the pulse
coder 20 produces the position pulses PP and the
one-revolution pulses. These enter a pulse distributor
of a feed motor and, in a thread cutting machining

operation or the like, are employed in rotating the

feed motor in synchronism with the spindle. It should

be noted that the command unit 11a, DA converter 11e,

speed control circuit 12, adding-subtracting circuit

5 13, DC motor 14, tachogenerator 15 and pulse coder 20

are components already possessed by the prior art to

control the speed of a spindle by direct command.

In the position control mode, on the other hand,

the command unit 11a issues the spindle position

10 command SPC. The register 11b, it should be noted, is

constantly registering the actual position AP of the

spindle by reversibly counting, in accordance with the

direction of spindle rotation, the position pulses PP

generated by the pulse coder 20. The arithmetic

15 circuit 11c computes the positional offset PER between

the spindle position command SPC and the actual angular

position AP and delivers the positional offset PER to

the DA converter 11e through the switching circuit 11d.

The DA converter 11e converts the positional deviation

20 PER into an analog value which it delivers to the

adding-subtracting circuit 13. The latter computes the

difference between the positional offset and the actual

speed voltage TSA and applies it to the speed control

circuit 12, which controls the rotation of the spindle

25 17 in such a fashion that the difference approaches

zero, with the spindle being brought to a stop at the

commanded position.

In accordance with the present invention, a

position control loop can be formed merely by providing

an NC, adapted to control the speed of a spindle by a

direct command composed of an S instruction and four

digits, with the register 11b for storing the actual

5 angular position, the arithmetic circuit 11c for

computing the positional offset, and the switching

circuit 11d, making it possible to control both the

speed and position of the spindle through a simple .

arrangement. In other words, both speed and position

10 control are made possible through the addition of very

little hardware. Furthermore, if the NC has the

construction of a computer, including a processor, a

control program memory and a data memory, then the

arithmetic circuit, switching circuit and register need

15 not be specially provided. Instead, control of both

the spindle speed and position can be achieved merely

by a slight modification of the control program. In

view of the fact that the position control system for a

table, tool or the like, driven by a feed motor, is

20 entirely the same as the above-described position

control system for a spindle, the creation of very

little software will enable control of both speed and

position.

Industrial Applicability

25 The present invention provides a numerical control

device which, through a very simple method and very

little additional hardware or only slight alteration of

NC software, enables both the speed and position of a

spindle to be controlled. The invention therefore has a high degree of industrial applicability as it permits numerical control to be executed quickly and accurately.

CLAIMS

A numerical control device having spindle speed
direct command means for directly commanding the speed
of a spindle, and position sensing means for sensing
5   the actual angular position of the spindle, character-
ized by the provision of means for generating a
positional offset between a commanded angular position
and the actual angular position, and switching means,
wherein, in a spindle speed control mode, a speed
10 command issued by said spindle speed direct command
means is applied to a spindle speed control circuit
through the switching means and, in a spindle position
control mode, said positional offset is applied to said
speed control circuit through the switching means, said
15 spindle being brought to a stop at the commanded
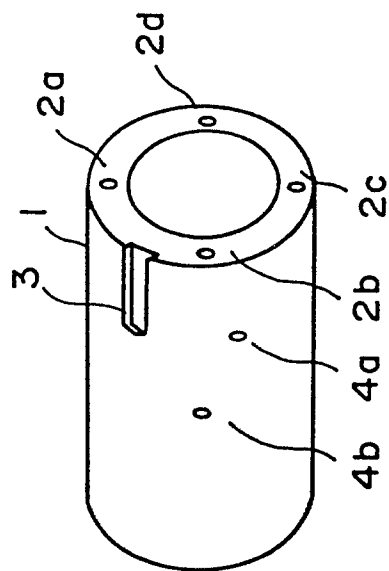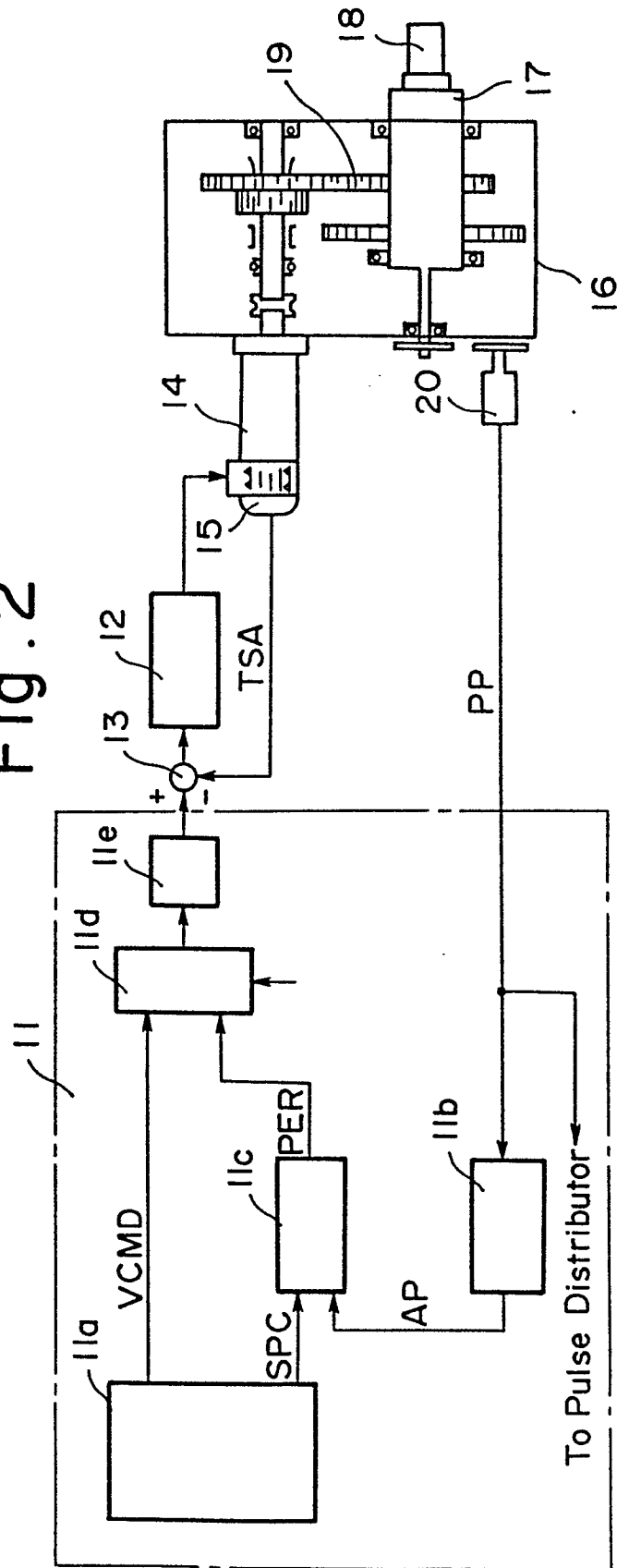angular position.

Fig. 1

Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No. PCT/JP82/00177

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[3] G05D 3/12

II. FIELDS SEARCHED

Minimum Documentation Searched [4]	
Classification System	Classification Symbols
I P C	G05D 3/00, G05B 19/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]	
Jitsuyo Shinan Koho	1965 - 1982
Kokai Jitsuyo Shinan Koho	1971 - 1982

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category*	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	JP,A, 54-67967 (Komatsu Ltd.) 31. May. 1979 (31.5.79)	1

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
August 9, 1982 (09.08.82)	August 16, 1982 (16.08.82)
International Searching Authority [1]	Signature of Authorized Officer [20]
Japanese Patent Office	

Form PCT/ISA/210 (second sheet) (October 1981)